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RANDOM THOUGHTS ON BALANCE.

President's address to the Birmingham Section, by W. G. Groocock, Section President.

IN my address to you to-night I want to deal with a few random thoughts on balance, giving simple illustrations to show how balance, or lack of balance, may in many ways affect production. In dealing with this subject I propose to take full advantage of my position as your President, inasmuch that I shall ramble more or less from one point to another. In the course of this address I intend to raise a number of debatable points, and I claim the privilege of doing this without attempting to supply the answer.

In the first place I propose to go over a few of our simple shop problems and develop them with the object of showing that lack of balance may affect our efficiency in several directions. In the second place I want to deal with a few phases of incorrect thinking, again with the object of showing that an unbalanced condition is particularly detrimental to us on the production side and also on the managerial side. Finally I want to say something about human aims and how these are closely connected with us as production engineers.

Dynamic Balance.

May I first of all mention a fundamental connected with balancing. Most of you are well aware of the effect of speed on balance. Take the case of any rotating mass, and so long as the centrifugal speed is not high, then the effect of an unbalanced condition is neither important nor very noticeable. When, however, we raise the speed of the rotating mass, the out of balance begins to make itself felt and there comes a time when something is likely to happen. Either the rotating mass vibrates so badly as to cause trouble in the bearings, or alternatively there is a fracture in the shaft. The point about this is that the rotating mass may be very badly out of balance if the speed is low with no serious consequence, and indeed quite often without it being known that the mass is out of balance. Change of speed, however, instantly shows up the out of balance condition.

Balance in the Shop.

Now this is a type of condition that may easily obtain in a small works, where, owing to rate of progress through the shop being slow, those in authority do not realise how badly out of balance

18th March.

the plant is, but as soon as acceleration is needed, then the out-of-balance condition becomes apparent. This is particularly noticeable if a rapid change is required. If we take a works where normally the work is put through in small batches with ample time for moving the work between operations, and from operation to operation, there may be a serious unbalanced condition of parts without any trouble being caused, but when it is required to pass the work through the shop quicker, then it soon becomes apparent that parts are missing, or some parts flow through quicker than others with a consequence of a shortage in the assembly stage. When the change in rate of progress through the shop is only a moderate one, this out of balance condition is not very serious, but when the change of rate desired is high, then the unbalanced condition becomes apparent at once and becomes also serious.

Balanced Production.

Another point where lack of balance may lead, if not to disaster, to considerable disorganisation, also applies to those cases where the product is made in batches, but where the assembly is also in batches. The component parts for making the apparatus usually go through in batches from the foundry to the machine shop. In the machine shop they pass step by step through a series of operations. At each machine there are batches and frequently there is a considerable loss of time between each operation. Finally the parts (most of them) required for an assembly reach the finished-part stores, and are then grouped ready to be sent out for assembly. Often it will then be found that certain components have either been forgotten or have been scrapped in the process of manufacture up to this stage. Sometimes the quantity available is more than sufficient to cover existing orders. On the other hand there are times when this shortage, or lack of balance, may cause considerable loss. The replace parts have to be ordered and rushed through the various processes. More often than not, overtime is worked all along the line to get such parts through. Going through in smaller quantities than usual they cost more per piece because of the relative cost of set-up and the overtime which may be necessary at any or all of the stages. Quite possibly in such cases there will be time lost in completing the orders, and finally a distinct monetary loss occurs through tie-up of idle capital due to a number of the components having been made before they could be used.

I sometimes feel that we do not always realise that an unbalanced condition such as this is losing us money, and even if we ever do think of the possible loss, I fear that very few of us do appreciate the magnitude of such loss. In this kind of working there is another loss which will cause an unbalanced condition, and this is the loss in time. Usually our customer spends considerable time in writing

us with regard to the delivery of the article that is behind. It may be, too, that he is a considerable loser because of our unbalanced condition. This may lead to loss of future orders. You may wonder what is the point of my remarks. They are directed, gentlemen, to this primary fact. None of you would agree that the condition I have outlined could ever exist in the factory, or department, under your charge. I hope you are right, but I believe that many of us are at fault, and I cannot put too much emphasis on the need for production men paying every attention to this side of their work with a view to getting as good a balance as is possible under the conditions imposed on them.

Floods.

Now I want to say something about floods. I wonder if you have ever noticed how close a similarity there is between a river and a workshop arranged along orthodox lines. In the river we have a channel designed by nature to take away the normal rainfall of a district, and periodically, owing to abnormal rainfall, there is flooding over very wide areas served by the river. These conditions are almost identical with those that exist in a normal works. We may have an equipment laid out to handle a given amount of work at a specified rate of flow, and just as is the case of the river when there are abnormal rainfalls, so in our works, if there are abnormal rushes of work, or sudden increases in orders, the works cannot handle them, and instead of taking their usual course, the various parts of the apparatus are apt to flood all over the shop.

Floods, as we know, may be very serious affairs and may cause considerable loss of money, but there is with the flooding of land compensation sometimes, because the crop from meadows that are periodically flooded is not only larger than normal, but sometimes of a better quality. Now this is where there is a wide difference between the flooding in the meadows and the flood in our works. There is no saving grace at all to the flood in our works. As soon as it occurs it causes financial loss. If it is long continued it is likely to cause considerable loss, not only in the section where the flooding occurs, but in other parts of the organisation because of its disturbing effect on other lines of work. When there is a flood, what are the usual actions that are taken ? So far as my experience goes, unless river floods are anbormal no action is taken, but under abnormal circumstances when, owing to inundation causing serious loss, probably loss of life, then the river channel is cleaned out so that the amount of water that can pass is greater. Obstructions such as corners are cleared away, and in many cases embankments are built so that abnormal amounts of water can be carried down during flood periods.

If you look at it closely, this is just the kind of action that we take

with regard to the works itself when we get flooded. If we examine the situation and find that the work jams at a certain point, we either put in another machine to take care of the load at this point, or we work overtime, or we put on a double shift. They are the usual methods that we take, but generally, I am afraid we do not realise quickly enough that there is going to be a flood, and a considerable amount of damage is done before this realisation comes to us and we take steps to ease the situation. Timely warning from our sales organisation that floods were likely to occur would be of considerable help.

The importance of tackling such floods at an early date cannot be over-estimated, and when the situation is being thought over, many considerations will have to be taken into account, and it is here that good balance is required. On the one hand we may—to take care of the situation—put in extra machine tools involving us in serious capital outlay, which would be all right if the flood of orders continued, but which is wrong—definitely wrong—if the flood is only temporary. On the other hand, if we have to put in overtime, or nightshift, we are paying premium time for the time thus spent, and we all know that overtime and nightshift work is not so efficient as day work. It means, therefore, that the most careful thought must be put into such a problem as and when it arises.

Now there is one other point where there is very close resemblance between the river and the works. When the flow of water down a river is below the normal we get stagnant points in the river. We get all along the banks, particularly at these stagnant points, a rapid growth of weeds, and this growth of weeds is particularly detrimental when the river fills up. The weeds may even cause flooding when the flow of water is only normal. This is exactly what may take place in our organisations when we are working below our normal level. If there are stagnant points in our organisation which grow weeds, then our human material at these points deteriorates unless there are periodic reviews of the situation with a view to keeping them up to the mark. If these stagnant points in our organisation are allowed to persist they will have the same effect on our normal flow of work as would weeds in the river. My advice to all who have control of sections that are working below normal is that this period is the danger period for stagnation in staff mentalities. It is the time when balanced thought is very necessary.

Improved Machine Tools.

One of the factors that production men have to study very carefully is that of improved machine tools. This is a very important side of their work. It is also one side on which we are apt to get out of balance. A machine tool salesman comes along and shows

us a machine tool that will definitely do the work in half the time of the one we have in use. It looks a good proposition. It looks as though it might pay to instal this machine, the cost of which is, say £2,000. Yet when we come to examine it—if we do examine it—we find that it will not pay us to turn out the existing machine to put this one in place. Why? I will give you an illustration.

The labour costs on a certain piece of apparatus were 15 per cent. of the total cost, and of this 15 per cent. which goes into labour, less than one-third was used in the machine shop. This means then that only five per cent. of the cost of the article was spent in the machine shop in direct labour. Now quite obviously, any one machine tool in that machine shop would only represent a small fraction of that five per cent. direct labour, and consequently, the most efficient machine tool in the world would have little effect on the total cost of that particular article. The point where balance is required when considering machine tools is that we must differentiate between those cases where we put in a machine tool because we need extra equipment, and the other side where we put in a machine tool because we can justify the cost of scrapping an old tool and replacing it by a more modern one. There are always plenty of cases where justification exists for scrapping the old tool and replacing with a new one, but there have been far too many cases in the past when machines have been taken out and replaced by new when the capital expenditure could not be justified. This is a case where balance is absolutely necessary, and the balance that is required is balanced thought from the executive who has a final decision as to whether old machines should be replaced or not.

Balance in Lighting.

Another point where balance, or lack of balance, can seriously affect production is in the method of lighting, either in works or offices. If the light is poor, that is, poor visibility, either by reason of not having a sufficiency of light, or light that is badly distributed, then the employees are working under poor condition, and cannot, even with the best will in the world, give of their best. Under such conditions, not only will their work be poorer in quality than it would be under good lighting conditions, but—and this is very important—they may gradually get soured and despondent. Poor lighting has had a good deal to do with turning good, honest workers into despondent dodgers. On the other hand too much light, or badly directed light, can be almost as bad in its effects as if there were not sufficient illumination. What is wanted, of course, is a balanced condition. Very few managers really realise how important the question of lighting is in connection with production, that is, production of the maximum amount of work of the necessary quality.

This desirable end can only be achieved when all conditions that can affect it are the most suitable that we can have, and undoubtedly, from the point of view of maximum production, good or bad lighting is sure to be one of the determining factors.

What is Maximum Production?

Maximum output per individual engaged, or per square foot used, is reached when we have a balanced condition, and this balanced condition could be said to be possible of achievement when we have a combination of the four following factors: (*a*) A suitable article to produce; (*b*) a definite manufacturing programme; (*c*) a works and equipment that is suitable for the product to be made; (*d*) an efficient organisation.

If we were to review the combination of circumstances that exist in a large number of works, we should find that the reason they do not attain to a very high degree of efficiency in their outputs, is due to an unbalanced condition as between the factors that I have mentioned. In many cases we should find that there was a suitable article to produce, that they also had a works and equipment suitable for the product that they had to make. We might also find that they had an efficient organisation, but that they were defiicient in the most vital of all the points, namely, they had no definite manufacturing programme. A large proportion of our works to-day are suffering under this disability. They have to muddle along without any true knowledge of the problem that is facing them.

There was a time when production was not up to the requirements of the world. To-day the situation is reversed and the problem now becomes one of estimating clearly and accurately what will have to be made, and this estimate can then go forward to the works as a definite programme for them to live up to, both in quantity and time. There is no possibility at all of efficient manufacture unless there is a definite manufacturing programme. All of us know the importance of having a drawing to show us exactly what we have to make. The more knowledge we have of what the designer had in mind, the less likelihood there is of having mistakes made in making the article.

The manufacturing programme stands to the production engineer in exactly the same position as the drawing to the tool maker. Any good tool maker will make a fairly good tool from a poor drawing, but he will make a more efficient tool and make it cheaper when the drawing has been well done. Now this is also the condition with regard to the production man and a manufacturing programme. A production man who knows his job can produce a whole series of articles without a manufacturing programme, but he will never get maximum results from his factory or organisation unless he

has what I call a drawing of his business, namely, a programme outlining: First, the article to be made and its variations, if any; secondly, the quantity to be made; thirdly, the time in which they are to be made.

Unless he has this he cannot even tell whether he has a suitable works and equipment for producing what is required. Further, he cannot know with certainty whether his organisation is suitable for what he has to do. All he can do under such circumstances is to keep on making changes, both in layout and organisation, as the situation demands, doing his best to keep a balance between various conflicting sets of conditions. He may get fairly efficient results under the conditions imposed on him, but he can never approach the efficiency that could be reached under a properly conceived plan built up from a full manufacturing programme.

Obsolete Equipment.

For a long time now there has been a constant repetition in the papers of the statement that industrially we in England are going backwards, and such a statement is usually followed by the further statement that our backward position is due to obsolete equipment. While this may, or may not, be true, the proper interpretation of the term "obsolete equipment" is not always well understood. Most people think only of the actual physical plant in factories and forget the larger aspect which embraces the whole of the organisation. We have been told so often that we are inefficient that most of us begin to realise something of our inefficiency, but we who are closely in touch with the actual workshop conditions of this country of ours; we who know that we do still continue to use long obsolete machinery, also know that much of this machinery is the machinery of organisation; of management; of sales. There is, no doubt, much that is out-of-date, but this obsolescence is not wholly concerned with our physical plant. May I suggest to you that an up-to-date works with a poor directorate is just as likely to get into the bankruptcy court as an up-to-date directorate with a poor works equipment and organisation. Many of us remember firms who have dropped out, where a first-class direction has been coupled with high-class management and workshop efficiency, but a poor sales policy has let them down. What is the answer? The answer is that too often there is an unbalanced condition; that unless this unbalanced condition can be rectified, then there is likely to be trouble. This is just as true in an organisation as it is with a rotating mass.

Wanted—a Technique of Distribution.

There is a growing opinion, not only in this country, but in America, that what we are suffering from most at the present time

is that there seems to be no co-ordination between production and its distribution, and it would appear that what is needed is a technique of distribution : something that will deal with this matter of distribution in a more scientific manner than it is being dealt with at the present time. The statement has been made on many occasions recently that whilst production has for a number of years been steadily going forward—that whilst production engineers have been straining their utmost to reduce the cost of production to its lowest limit, the distribution side has been definitely standing still. It is, of course, well-known that whilst the cost of production is going down, the cost of distribution is going up. In many cases it is going up, not only as a percentage, but as a definite amount.

The opinion of two professional men on this subject is worth quoting. Recently I had the pleasure of listening to a lecture by Professor Burstall on the " Future of Industry," and during his remarks he mentioned that while labour costs were still important in some respects, they were not nearly so important to-day as they were a few years back. In many cases the labour cost of an article is so small that it can almost be ignored. The vital point is the overhead that is attached to such costs, and in particular, the cost of selling, which is often so high that the price of the article to the consumer is almost prohibitive. Professor Elliott D. Smith, of Yale University, is reported to have said that : " When we shall have applied the same sort of technique to management and merchandising that we have to apply to production, we may expect to hear no more of the complaints against the engineer for causing technological unemployment."

Here then, we have the opinion of two professional men ; men of standing who would not have spoken unless they had studied the subject ; men whose stated opinion definitely shows that there is something out of balance. This out of balance condition does definitely affect us as production engineers. It is, of course, also vital inasmuch that it effects world conditions. Opinions differ as to the failure of our schemes of distribution, but one opinion that is frequently mentioned is that our larger organisations, owing to their constitution, lack the vision of those pioneers who made England great. Too much proof is needed that a vision will be successful, and this often prevents any action being taken at all. This would appear to suggest another unbalanced condition, namely, that in business to-day there is too much of the actuary and too little of the visionary.

Mechanisation.

May I now for a moment or two deal with the question of mechanisation. We often hear people deploring the loss of craftsmanship, a loss which is supposed to be the result of mass production. Another

statement that is frequently made is that the machine-made article which is rapidly displacing the hand-made one, has been the means of lowering the quality of workmanship. May I take these two points and review them from certain angles to show how perfectly futile both views are.

In the first place I want to repudiate the idea that the machine made article is inferior to those made by hand. This idea is so entirely opposed to facts that wherever it persists, then you may be sure there is an unbalanced mentality. Since the introduction of the machine there has been a steady and continual improvement in the standard of output of every commodity that helps to make life brighter. Running parallel with this improved output we have had at all times an improved standard of quality ; a quality in the majority of cases which can only be achieved by the use of the machine. We have the well-known fact that one of the earliest difficulties of Watt in bringing out his steam engine was the failure of his early attempts to bore his cylinders, and it was not until Wilkinson invented his boring machine that Watt was successful with his steam engine. Since that day this condition has been multiplied innumerable times. Anyone who knows the mechanic's business knows that our present position could never have been achieved at all without the use of the machine, and in many cases where we could have got something of the same kind, then the cost would have been so extraordinarily high that we should never have progressed, simply because the market would not have been there for our goods.

The Craftsman.

It is a mistake also to think that mechanisation tends towards the elimination of either the artist or the craftsman. For instance, most of you have seen recent reproductions of the work of artists who have long been dead. These reproductions may take the form of etchings, or of coloured pictures done by the three or five colour process. Now it is a well-known fact that many of these reproductions are more nearly true to scale and to colouring than were the originals. The men who are doing the preliminary work for these processes are artists in the true sense exactly as were those who made the original drawing or painting, but the mechanisation of production has made it possible to place copies of those works into the homes of the masses instead of confining the work to either the homes of the rich, or in picture galleries.

In what way then has the mechanical process done anything to reduce the importance of the artist. Looked at from the point of view of payment for work done, there never has been a time when the artistic sense of conception and execution gave greater monetary returns to the artist than is the case to-day. If then the work

of the artist is made available for more people to enjoy, and if, further, the artist is better paid than he used to be, how can it be said that mechanisation is gradually eliminating both the artist and the craftsman. It is not true, gentlemen, and the statements, when they are made, arise from lack of balance on the part of those who make such statements.

On craftsmanship alone, and confining it to our own business, there is no foundation in the statement that there is lack of craftsmanship. There is, however, a displacement of craftsmanship owing to the re-arrangements in the methods of doing the work. We can now, when the work is of a repetition character, do without the skill of the craftsman in the machine shop, but in such cases we need his help in the tool room. I want everyone present to realise this fact, that somewhere in our organisation we ought to be building up craftsmen all the time. We are. We take an unskilled man; we put him on to a group of automatics; if we are wise we train him along certain lines. Eventually that man, who was once a labourer, will become a skilled mechanic. Skilled probably along a narrow line, but with the skill that is higher than could possibly exist if his training was made more general.

To-day is the age of the specialist, and while there are some people who are foolish enough to think that specialisation in the machine shop deadens the mentality, such people are back numbers, and if they would only examine their own mentality they would be rather surprised at their lack of balance. I have a working knowledge of the mechanic's business that covers nearly half a century, and my experience is that the mechanics of to-day—that is, our millwrighting and tool room force—are, as craftsmen, better than the mechanics of the past. There is, however, definite evidence that the skilled mechanic of to-day—the man with an all-round experience—is relatively worse off from a monetary point of view than he was forty years ago, that is, if we compare his rate of remuneration with the labourer of these two periods.

There is something definitely out of balance in this question of remuneration. Many of you have working for you highly skilled tool makers, also highly skilled millwrights, men who are paid something above the basic rate of their grade, and yet these men are drawing no more each week then the municipal employee who is sweeping the street. On the other hand, we know that Jackie Coogan is drawing a salary many times larger than that paid to the President of the United States. We can easily see, therefore, that there is an unbalanced condition. As I mentioned at the beginning, I am not going to supply the answer. In this particular case I could not if I wished, but I feel that before we can have a properly balanced world, we must get rid of some of the anomalies of unbalanced remuneration.

Human Aims.

In dealing with this side of my subject it will be well to start with a fundamental—something that is not changed by circumstances—something that is true whatever our walk in life may be. True also whatever may be the particular line of product that we are making, or thinking about. The fundamental which I have in mind is that the majority of the human race are desirous of a better standard of life. We are all agreed that before we can obtain an improved standard of living we must have a greater output of those commodities which are necessary to improve our condition. We are all agreed, I think, that the human race as such, is willing to work to obtain these extra commodities. That is the fundamental we must always keep before us when we are thinking of human beings and their requirements.

Human beings as such are constantly striving for some condition slightly in advance of that which they are living under, and there is no limit to what may be achieved in the way of a higher standard of life, if all are agreed to work for what they require. There may be—quite possibly is—an unbalanced condition between the work they do and what they obtain for it, but the basic fact remains that humanity is steadily going forward and achieving a better standard of life.

It has been said that the standard of living of a people engaged in industry may be accurately gauged by the quality of labour saving machinery utilised per worker in that industry. I have heard it stated also that you can judge this from the standpoint of what power, either steam, electrical, or other is used per head of the country under consideration. We know that the United States of America uses considerably more power per head of population than we do. We know too that the standard of life measured in commodities is higher in America than it is in England. It may be impossible at the moment to achieve a much higher standard either in America or over here until something has been done for those races of mankind who at the present moment have a standard of living that is extremely low.

The true function of nations who have a high standard of life is undoubtedly to work for a gradual raising of the standard of living for the whole of the world. Unless this is done, an unbalanced condition is likely to exist, and in my opinion that is exactly what is happening to-day. In common with others we as a nation have been keenly desirous of raising our standard of life, and in doing so, have been, I fear, callous as to the standard of life of the rest of the world. From such a condition there are bound to be reactions, and these reactions throw the whole scheme of things out of balance.

The World's Problem.

The problem of the world to-day appears to be in finding employment for its people. Whichever way we look at the problem we find contradictions that seem to suggest an unbalanced condition. What has really happened is that the rate of change, or increase of speed of production, is now showing up a badly balanced condition that has existed for years, but was not so apparent when speed or output was lower. The situation is similar to the condition observed in a rotating mass. We are told by industrialists who should know that what the world is suffering from to-day is over-production. How can we square over-production with a known desire of our people, and other people, for a better standard of living? Have we all we need? My own view is that we are not suffering to-day from over-production. What we are suffering from is an unbalanced production; a surplus of the things that either are not required, or which are produced at a price which places them outside the purchasing power of those who want them. Alternatively, our markets are restricted by the decreased spending powers of those who otherwise would purchase these commodities, and our best efforts as a nation should be directed towards an enlargement of our markets.

As I said at the beginning, I do not know the answer to a number of things that I have been discussing. I do not know the answer to this particular one, but I do believe that we as production engineers are doing the right thing when we live up to the slogan which we have made our own, namely, increased productivity at lower costs, coupled with higher earnings for our workpeople. The lower costs of the commodities will enlarge the field, i.e., bring in more purchasers; the higher earnings of the workpeople will again increase the purchasing power, and this, of course, increases the number of those who will buy our commodities. We have, undoubtedly, as a nation, been very short-sighted in our method of handling this question of supply and demand. There is to-day an ever-increasing demand for certain classes of commodity, but the price must of necessity be within the purchasing power of the people.

Increase in Productivity.

You may wonder why I have been dealing with human aims and the world's problems. Probably you wonder what connection there is between the production engineer and these two factors. I mention them because when taken together they show that there is somewhere an unbalanced condition. We as production engineers are being called on to satisfy the need of humanity for a higher standard of life, and to satisfy this need we aim at producing more and still more per individual, or per square foot of floor area. Yet

we are told that there is over-production. The situation appears to be worthy of Gilbert and Sullivan. It is true that we as production engineers do hope to assist towards a higher standard of life, because all our efforts are directed towards greater and still greater production of those things required. Personally I cannot think that we have yet reached saturation in this respect. The trouble is not over-production, but under-consumption, and this is due to insufficient purchasing powers.

Recently I had a talk with a man engaged in engineering, who definitely stated, and apparently believes, that we have gone too far in our labour-saving methods of production. He put forward all the usual pleas that improved methods displaced labour, and as this displaced labour had to be kept we might just as well employ a larger number by using less efficient machinery. Here indeed we have a lack of balance ; a mentality that is out of tune with realities ; a mind that is static, or worse. It is a curious fact that this type of mind can persist in spite of the evidence we have had for over a century that labour displaced at one point by more efficient production, eventually gets absorbed at some other point. There is, of course, always a lag and national means ought to be taken to make such lag as short as possible. National means have already been taken, through the national insurance scheme, to help workers during the change-over period, and although this scheme is not being properly applied, it is in principle, correct.

When looked upon as a means for taking care of labour displaced by new methods, our scheme of insurance, properly worked, could be effective. I very much doubt, however, whether it could ever handle a situation such as we are suffering from at the present time unless, like all good businesses do, it builds up a strong reserve during normal and boom periods. The real point I want to stress here is that no matter how unbalanced the world's economic condition may be ; no matter how many people in our industry may be unemployed, the production engineer must always keep on working towards his main objective, namely, increased productivity with lower costs, coupled with, if possible, higher earnings for his employees. No matter what the world's condition may be ; no matter if there appears to be a surplus of the commodities that he is making, whatever conditions may exist, the production engineer must ever be alert and striving always for more and still more production per unit. This is the only way that the very human desire for a better standard of life can be achieved.

Quality First.

In the last of my random thoughts I would like to refer to what I think is a very vital point. I was recently listening to one of our industrial leaders who put forward the plea that whilst price

was very vital; while it was necessary that we should get our products down cheaper, it was very important that in our efforts in this direction we did not lose sight of the fact that quality must be maintained. He, Sir Herbert Austin, stated that England had achieved her industrial greatness mainly by reason of the quality of the goods she supplied. He stated—and I know you will all agree with him—that just as years ago the words "Made in England," or "British" stood for all that was best in quality of workmanship, so we must insist to-day that this quality is not sacrificed on the altar of cheapness. What we have to do is to maintain the quality that years ago gave England industrial prominence, at the same time bring down the cost of our commodities so that we can increase the size of our markets.

Once more we see that we have something to balance. On the one hand we must have a product cheap enough to increase our markets, on the other hand we must ensure that the best value possible is given in the way of quality for the article that we are supplying. A perfect balance is needed, and we production engineers must see that whatever we do to cheapen our product, the question of quality must have our very best consideration.

In conclusion, I would like to take this opportunity of placing on record how much I appreciate the help that has been given to me during the two years that I have had the privilege of acting as your President. I want to specially thank your Committee for the hard work they have done during these two years. I want also to thank you, gentlemen, for the interest you have taken in our Institution, and to express the hope that your interest will be maintained. Our Institution has great possibilities before it, but these can only be achieved with your assistance.

A METHOD OF MEASURING PRODUCTIVE EFFICIENCY.

Paper presented to the Institution, London Section, by R. E. Beswick, M.I.P.E.

IN venturing to describe to you the simple method that follows I am far from making any extravagant claims whether on the score of originality or importance. Indeed I am aware that there are available to-day systems that resemble it closely at points, and that have been carried to a stage of far greater complication, though I am not entirely prepared to agree that any with which I am familiar serve quite so effectively the needs of the production engineer. Whether this is so or not, I have been bold enough to hope that there may be some interest to our members in a description of the way the problem of securing a practical measurement of manufacturing efficiency has been tackled by one individual member, working on such lines as have suggested themselves to him, without outside advice or assistance, and, I am afraid I must confess, without paying the least attention to what was being achieved by other more powerful workers engaged on similar problems. If I am found, then, to be covering ground already adequately exploited, I trust there may be sufficient novelty in my homespun methods to render them interesting and to protect me from accusations of plagiarism. If not I must ask you to accept my assurance that my own experience commenced in 1920 and had resulted in a working practice long before I had any acquaintance with any even remotely similar work.

I ought to make it clear at the outset also that in this paper I am dealing only with shops engaged in small manufacturing, that is, handling on a repetition basis a product as varied as you like but in which the quickest operations require a few seconds only, while the longest seldom exceed a quarter of an hour. There does not seem to be any inherent objection to its extension to slower processes, provided they are performed on a genuine quantity basis, but in order to obtain reasonable accuracy the periods over which the efficiency is measured would obviously need proportionately extending. On the small work with which I am dealing, it is possible to measure efficiency hourly. Actually my own practice is to record it weekly.

When I first thought of measuring efficiency some ten or more years ago I was stimulated no doubt by the prevailing urge for efficiency—in those days our industrial future was held up to depend on its achievement—desirous of introducing a competi-

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tive spirit between various shops all belonging to one organisation but engaged on work the nature of which differed widely from shop to shop. My idea at that time was to hold a competition for the most efficient shop, to exhibit the progress of the competition prominently in each shop, and at the end of a period to decorate the winning shop with a trophy which they would retain until their rivals succeeded in depriving them of pre-eminence.

The problem that at once arose was how should one arrive at a basis for comparing efficiencies. It was quickly evident that we all had our differing ideas about efficiency, and that while everyone at that time was talking about that mysterious quality, no one attempted to measure or record it. It at once seemed to me all wrong that efficiency in the production world should be allowed to occupy a similar nebulous position to that of grace in Theology or of sportsmanship in Athletics. An engineer at any rate should be capable of measuring and recording his efficiencies.

It looked, too, as if to be able to measure efficiency might free the production engineer from some of the superstitions that permeate his business—the superstition about Saint Monday, the superstition that Saturday morning work does not pay, that a shorter working week does or does not pay, that a ten-minutes break increases productive efficiency. Of course I do not use the word superstition in a condemnatory sense. Many superstitions are true, but when they are *proved* true, they cease to be superstitions. At this point it will be well to warn you that I do not claim to have solved all the above problems. It will, however, be obvious, I think that my methods supply a clean, simple solution where circumstances will permit of them being applied. In the days of which I am speaking, output was our accepted guide. We gauged our efficiency by the quantity of goods produced to a defined standard of quality. This was periodically checked by an examination of costs. Generally there was too great a lag in the cost check. By the time we were able to hold our post-mortems, the corpses had been too long in corruption. And beyond this there was no basis of quantity and cost for the comparison of shops that were engaged on dissimilar operations.

Considering the primary factors of labour and material it was obviously impossible to compare shop-efficiencies on a basis of material. There was too much variety and the wastage factor necessarily varied enormously. One had to accept material, as one also had to accept the plant and equipment, as being factors largely outside the control of the shop. It was equally obvious that there was little difficulty in the comparison of labour-efficiency which was, after all, precisely what was required. The shops were all on straight piece-work and of course were piece-worked by the stop-watch, that is, we had for every operation a carefully investigated time-basis.

Some times, no doubt, were a little generous, some less so, but on the average we did actually know the nett time required to perform each operation without fumbling, without easing up, blowing one's nose, or stopping to sharpen tools, adjust jigs, or enquire what won the 2-30. We had therefore a basis for determining the nett time-value of our output off each operation. We had also from our clock-cards the gross time expended in the shop. To express the one as a percentage of the other was easy, and we were at once able to define our efficiency as the percentage the nett time-value of the total operations performed over a given period bore to the gross time recorded on the clocks for the same period. There is really nothing more in it than that and its simplicity so expressed abashes me for my temerity in taking up your time with such an elementary matter.

As I have said, the thing was started as an inter-shop competition, but it soon became evident that it embodied results of the utmost value to the management, apart altogether from the competitive aspect originally aimed at. Since those days it has been applied in other shops and has been found to provide much valuable guidance of a kind not, I believe, commonly available. For example, as a bye-product it gives one a measure of the labour-value hidden in one's work-in-progress. It can provide for the purpose of estimates an accurate internal-loading percentage to cover the non-productive labour in each department of the works. It records the degree to which improvement or the reverse is being attained in the handling of the operators. There is a great satisfaction to have the evidence of indisputable figures showing, to take a case within my own experience, that the average productive efficiency of one's works has in three years been increased from 45 per cent. to 60 per cent., this being, of course, by definition entirely independent of improvements made in processes and equipment.

Now with regard to the actual methods, you will understand from what I have already said that it is with mixed feelings that I confess that these are quite infantile in their simplicity. There is no great display of printed forms to impress you, nor does the working out of the figures for a shop of about 150 hands occupy more than a quarter of one clerk. *The first essential* is to select a time unit. This will vary with the nature of the work. In one shop in the earlier experiment, it was a quarter of an hour's work. This shop was engaged in burning up the plates of fair-sized lead accumulators. More often it is less, and the most useful unit in the small manufacturing work, I have proclaimed my intention of discussing, is one minute's work. Whatever it is, we call it a " point," for simplicity. Taking the case where the time unit is one minute, then, every man-minute of productive work scores a point.

When the time-study of an operation comes in from the rate-fixer, the point-value and price to be paid for the operation are

worked out in this way.

Pieces per hour.	No. of operators involved.	Pieces per Operator —hour.	Points per 1,000 pieces.	P.W. Price per cent.
40	1	40	1,500	37/6
3,000	2	1,500	40	1/-
1,000	1-3	3,000	20	6d.

The first column is summarized from the time-study which also, of course, records the number of operators. In the first case listed the operation is performed by one man. In the second it requires two, while the third is a case where one man minds three machines. The third column explains itself. It is obtained by dividing the first column by the second. The fourth column is obtained by performing the simple sum : Minutes per hour ÷ pieces per hour × 1,000 = minutes per 1,000 pieces. The result represents the number of points allotted to every thousand pieces operated on, a point being by definition a man-minute of productive effort.

The prices in the last column have been calculated on the basis of 25/- per 1,000 points. The obtaining of such a basis is a matter of supreme importance but fortunately of no great difficulty. It obviously depends on the class of labour employed, the district rate, the desired margin of incentive, etc. I will return to this problem later.

Three widely varying jobs have been chosen for illustration, but variations a great deal wider than this are common and need cause no trouble. It is not necessary to use any actual division into columns, and with a little practice the figures may be done in one's head. The piece-work price-sheet referring to the highly imaginary job of which the chosen operations are a sequence would read somewhat as follows :

Op. 1. Capstan (Herbert No. —)
Chuck, centre, drill and tap.
40/1/40/1500 ... ... 37/6 per cent.

Op. 2. Assemble with spring (Fixture No. —)
3000/2/1500/40 ... ... 1/- per cent.

Op. 3. Spin. (Auto-spinning machine, hopper feed)
1000/1/3/3000/20 ... ... 6d. per cent.

When the calculated number of points is uneven it is convenient to add another figure bringing the points allowed per 1,000 to the nearest multiple of 5. Thus :

Op. 6. Sensitive drill.
Drill two quarter-inch holes in Jig No. —
239/1/239/251/250 ... ... 6/3 per cent.

On the other hand in extremely rapid jobs it is sometimes necessary to calculate to a fraction of a point.

When one has piecework price-sheets such as the above prepared, filed and indexed, for every product or component of a product, one has for each operation two important figures readily available—the price and the point-value, and each of these is very easily convertible into the other. My experience is that one will in a short time find oneself regarding the point-value as the really important figure, to such an extent that one estimates in points, and speaks of " an 800 point operation " instead of " a 20/- a thousand " one.

I have defined the first essential as the selecting of a time-unit, the *second essential* will be seen from the above to be simply a handy formula for calculating our point-values and piecework prices from the time-studies. The *third essential* is no more than the usual returns from the shop, required for the making up of piecework payments and the provision of output records, together with the time recorded on the clock-cards. In a straight individual piecework shop where the period chosen coincides with the pay-week, one has only to total up one's piecework payments and convert the total into points to secure the nett time-value of the piecework effort. Where the wage-system is more complicated one has, in addition to calculating wages, to calculate the time-value of the output in points. In any case what one obtains from one's point total is the nett total number of minutes required to perform all the operations that have been performed in the week, at 100 per cent. efficiency. If one now totals up the clock-cards and expresses the total in minutes one has the gross total number of minutes that have been employed in performing all those operations. The ratio of the *nett time required* to the *gross time recorded*, expressed as a percentage, is the efficiency of the shop for the period under consideration.

I find it useful to keep at least two efficiency records, a general record and a purely operator record. For the latter I simply record the times and outputs of the pieceworkers or operators. For the general record I include in the gross time totals the times clocked by all accessory labour such as porterage, setting, floor-inspection, shop-cleaning, etc. Whether one needs to include millwright's and toolmaker's time depends on individual conditions. It would be just as easy to include them all, but in some instances, particularly in the case of the tool-room, it might be misleading, as a large proportion of their output goes to capital account, and their work not being repetitive is not time studies nor assigned point-values for inclusion in the output.

The general record can obviously be of great service in gauging the effect of changes. Should one have to make a change of foremen one can compare, for example, the efficiency of the new man's section with that under his predecessor. That will tell one a lot

more than the glibbest tongue or the most impressive display of energy. Is it a question whether an increase in carriers or an addition to the setting force would be an advantage? An experiment will tell one in plain figures, for either one's general efficiency remains the same after the change or shows an upward or a downward tendency. Were a firm to change over, as I think firms increasingly will, from a five-and-a-half-day week to a five-day week, they would, by measuring their efficiency before and after the change, have something very definite to justify or otherwise the enthusiasm with which such improvements are commonly greeted.

The utility of an efficiency record extends beyond the manager's office. It can assist both costing and estimating departments. For, given the labour value of any job and the general efficiency of the shop or section, one clearly has a much more accurate idea of the amount to be plussed for one's internal or shop-loading than is customary in shops where highly developed costing systems are not available, and in some where they are. For example, suppose the operator efficiency of a section is 80 per cent. and the general efficiency 55 per cent., the difference of 25 per cent. is accounted for by the non-productive services—25 per cent. : 80 per cent. as 31.25 : 100, so that the internal loading to cover all indirect and waste labour is 31.25 per cent.

An efficiency record can also be used to provide us with a measure of the labour value of our work-in-progress. This it exudes as a sort of bye-product. In gauging the value of a week's effort by the output we are always up against the floor-stock difficulty—how much more or less labour has been put into work-in-progress this week than last week? Unless we take stock the labour value of our work-in-progress is always one of our unknown quantities. Its material value we can always gauge from our stores issues and receipts. One should get an accurate figure for the labour-value of work-in-progress at stock-taking. Thereafter, one can trace its variations weekly if one determines the difference between the point-value of the week's finished product and that of the week's operations record. We have our output return of finished products. We have our return of operations from each machine or operator. We have also the point-values of both individual finished products and individual operations in the form of a convenient chart or table. If the total point-value of our operations is greater or less than the total point-value of our finished product their difference is obviously the point-value, or number of minutes of productive work, that has gone to increase or decrease our work-in-progress. If we know the relation between points and piecework payments, that is the price-basis we discussed earlier and assumed to be 25s. per 1,000 points, we know the wages-value of the variation of work-in-progress for the week. We know whether the improvement the output

appears to show, for example, has been gained by concentrating on final operations, or if it really is due to an extra effort on the part of the shop. If the latter is indicated by a steady or increasing floor-stock we shall turn to our efficiency return for the week and expect to find that it records a rise.

With these three records the general efficiency, the operation efficiency, and the work-in-progress variations, believe me, there is not much one does not know about the performance of the shop. If the shop were a power house in which one was consuming coal one would expect such records. Everyone insists on them from the power house. My object is to show that they are just as easy to obtain from a factory which is consuming labour, and a great deal more important and illuminating.

Apart from the general guidance that an efficiency record supplies to the management it does, of course, supply some interesting individual results. Those I am about to give you suffer, of course, from being the product of one man's experience only. If fifty different factories were recording similar matters and the records were being compared I imagine the results would provide a more solid basis for industrial reformers than any they now possess. Unfortunately speaking in the broad sense (there are compensatory aspects) my own experience has of late years been somewhat stable and limited to one particular type of shop and range of circumstances. There have not, therefore, occurred to me opportunities of solving some of the more interesting and vital problems such as I briefly referred to in my opening remarks. I think you will agree, however, that such problems can be solved by the measurement of efficiency, given the necessary circumstances.

With regard to actual results, in a shop equipped with automatics, capstans, milling machines, drills, presses, and general plant the average recorded general efficiency for the whole of the labour, productive and non-productive, with the exception of inspection, is 60 per cent. It may rise to 61 per cent, a great effort is being made to get it to rise higher, it may drop under adverse influences as low as 50 per cent. The operator efficiency varies from bay to bay. For example, that of the milling bay averages 74 per cent., that of the light capstans 70 per cent., that of the sensitive drills 78 per cent., that of the presses 76 per cent., of the polishers 75 per cent. The average operator efficiency over the whole of the machines is 76 per cent.

In general, within my own experience, there is no difference in a shop that has a five-day working week between the efficiencies on Mondays and on Fridays. I have not had the opportunity of obtaining comparative figures for a five-and-a-half day week, or rather, when I had the opportunity I had not learnt the importance of ascertaining them and I missed my chance. I believe, however,

that most Saturday morning work would be found to be relatively inefficient. The apparent increase of efficiency on the last day of the pay-week is, to some extent, a myth, the rise of finished output being largely due to the tendency of the executive to concentrate on final operations. Short time I have found to tend to decrease efficiency. This I think is due to the tendency to try to obtain a full week's wage in the shorter period, being offset by the depressing knowledge that work is scarce and the consequent fear of dismissals if it is not made to last out. The reduction of the size of the orders placed on the shop with a view to reducing the amount of money locked up in work-in-progress has been found to reduce efficiency. Men seem to work better when they see plenty of work lying about. If a man is used to seeing two trays of work behind him he will work, slower when there is only one there. Any disturbance or dispute in which the shop is interested tends to lower its efficiency.

The introduction on one occasion of a five minutes break in a five hour shift had no apparent effect on the efficiency figures.

These are the sort of general observations that one is enabled to achieve with the aid of an efficiency record. They need checking, of course, against the experience of as many other investigators as possible before they can be taken as proven. In all work of this kind one needs what the scientific investigator terms a "control" before one's conclusions achieve validity.

I have dealt with the determination of efficiencies in conjunction with rate-fixing and wages systems, as there is a good deal of work that may be common and mutually helpful to all three, but of course there is no reason why efficiencies should not be determined independently of such concurrent systems, particularly if those in existence are less co-operative than the ones I have had in mind. No system of payment by results, however, can avoid the necessity for time studies even if these are of a comparatively elementary nature, and once one knows the nett time required to perform one's operations at 100 per cent. efficiency one may as well adopt a time unit, and a price unit per 100 or per 1,000 time units.

The determination of the time price relation is easily done if one has already existing piecework prices that one knows can be relied upon to give the workers earnings that are satisfactory to them and to the employer. If one has not such prices to guide one it is better to make a clean start, time-study one's jobs, determine their point-value, and employ this to measure the efficiency of the shop over a period of, say, one month. At the end of the month one will be in a position to piecework the shop with confidence that the results will be such as to ensure satisfactory relations on both sides. Where one has already available output records over a month or similar suitable period, one can use these in the office and work out the shop's efficiency for that period in the course of a single day.

One can ascertain the efficiencies of any dubious sections separately and, knowing these, one can prophesy with some confidence the earnings that will be reached on one's new price schedule further than the use of efficiency records to check one's prices. I have advocated, so far without rousing much enthusiasm, the adoption of a method of payment by efficiency. There is not time to deal with the subject other than cursorily to-night, but it does, to my mind, present some very attractive features, particularly when one is dealing with gang work. In a shop which was running on day work a few years ago I ascertained the operator-efficiency to be averaging 60 per cent. For the sake of simplicity we will assume that the day rate was 40s. I knew that the operator-efficiency under piecework might be expected to rise to the neighbourhood of 80 per cent. with high spots at 85 per cent. or thereabouts. It seemed ideal to say, "Very well. For an efficiency of 60 per cent. I will pay a wage of 40s., for an efficiency of 90 per cent. 60s., and for intermediate values in proportion." The figures are only given for illustration, but it will be obvious that one increases one's wages in direct proportion to one's efficiency increases. Unless one has made a severe error in one's price no operator can be expected to make 100 per cent. efficiency. (I have known this figure reached on a price that has been timed too generously or where the operator has improved on the manipulations that have satisfied the rate-fixer), that is it is practically an impossibility to make so much as time and two-thirds, while from experience it is safe to prophesy the average attainable earnings as about time and one-third or 80 per cent. efficiency.

In conjunction with such a system I proposed to pay the setters and carriers a rate which varied in proportion to the variation of the average efficiency of the operators they served. I believe this making of the wages of the services dependent on the earnings of the operators served, to be of very great influence on the efficiency of the shop. It prevents the envious spirit with which the day worker usually regards the pieceworker from resulting in a lackadaisical service, indeed, if their rates are not too disproportionate it eliminates the envy itself. This is a digression. To return to the subject of payment by efficiency determined in the simple manner we have been discussing, although I have not yet been trying out, and I can myself see no reason why it should not prove nearer the ideal system than any I have yet seen tried out.

Payment might alternatively be based on general efficiency, or more attractive still, on operator efficiency modified by reference to general efficiency. As an example suppose a man's direct earnings, either on piecework or on his individual efficiency as suggested above, were 80s. and the general efficiency 75 per cent., he would receive 60s., the rates, of course, having first been set to allow for

reduction to a figure proportionate to the existing general efficiency. Earnings would thus depend on two factors, viz., the effort of the individual and the collective effort of the shop. Under such incentives men learn to do little jobs for themselves instead of waiting for the setter; they give the next man a hand with a lift instead of waiting for the labourer; they discourage lavatory meetings, idling between jobs, and similar wasting of time, all because they have an interest in maintaining a high general efficiency. Payment on some such basis would ensure the co-operation of the employees in attaining the ideal Mr. Pucknell laid down in a recent paper to our Manchester Section, the ideal of higher individual earnings with lower production costs. No incentive scheme that relies solely on methods, machinery, and control to eliminate waste labour can be completely successful, for that you must have the operators with you.

In conclusion it will perhaps be as well if I say a word or two of warning against the tendency to apply one's efficiency returns too rigidly. It is very seldom that there is only variant circumstances in operation to inflate or reduce efficiency in a shop. One's results are generally complicated by considerations such as pressure of orders, shop temperature, volume of work in progress, the proximity of holidays, the spirit of the shop, etc., all of which may have had their effect on our efficiency as well as that particular change to which we are disposed to attribute the recorded variation. One has to consider these things carefully, and if possible make the same determinations at times when we know that certain causes of variation are no longer acting, before one can come to a valid conclusion. The value of our records, in other works will, like that of so many aids to production, be strictly proportional to the amount of brains we apply to their interpretation.

Discussion

MR. N. GERARD SMITH said that Mr. Beswick need not have apologised for what he had referred to as the " infantile simplicity " of his scheme, because simplicity was the hall-mark of genius. Inasmuch as the method supplied by Mr. Beswick was very much like the Bedaux method, and gave similar results, Mr. Gerard Smith made some comparisons of the two, though he did not claim to know a very great deal about the Bedaux method. Mr. Beswick paid for each one minute's work at a certain rate, and Bedaux arrived at the time occupied, in minutes, to do a job—which amounted to the same thing, practically, but Bedaux had been thinking of the slower jobs, whereas Mr. Beswick had in mind the rapid short-time jobs. The Bedaux system paid for 75 per cent. of the B's produced over 60 B's per hour—60 B's per hour being the standard—so that it was a bonus system and not a straight piece-work system. The remaining 25 per cent. went to indirect labour, as a bonus, and that was a thing which Mr. Beswick was aiming at. Both schemes gave a very good measure of the efficiency of the man and, in the aggregate, of the whole shop and the whole works, and both found the value of measuring staff—foremen, etc. Complications had been introduced into the Bedaux scheme, however, as applied in some shops, so that many figures had to be used in order to estimate the efficiency of those shops ; the simplicity of Mr. Beswick's scheme, on the other hand, was a great advantage.

Mr. Gerard Smith emphasised the warnings Mr. Beswick had given with regard to making comparisons on the basis of points. He pointed out that no shop would be making the same product continuously, and the products must change, which necessitated either a tightening up or a slackening down in rate fixing, so that direct comparisons were vitiated. Again, the rate fixing in one shop was easier than in another. The only really valid comparison seemed to be that of similar products, at the same rates, over varying times. Mr. Beswick had emphasised the importance of ascertaining the labour value of work in progress. That was not really difficult to obtain, but, after all, if one closed the shops weekly, debited an account with the total labour value and credited it with the jobs finished, one had a running inventory of the work in progress labour value. Again, as a measure of efficiency there was the piece-work balance ; i.e., for every piece-work job one also worked out the cost at day rate. One should have a certain value paid for piece-work, over and above the day-rate value at the same number of hours, and that was a very true measure of efficiency. It would be possible to go a step further than Mr. Beswick had gone, by making an analysis of idle time. He supposed that the efficiency of a department should not be debited for time lost as the result of the purchase department

not having the necessary material at hand. If one had a point value of the time lost due to such failure, or to the failure of the tool room to supply the necessary jigs and tools, and so on, one could definitely allocate such losses to the departments or individuals concerned. Finally, he said it was very useful to have a point value for the distribution of on-costs. One had only to divide the total on-cost value for a month by the total points produced during that month in order to get an allocation of on-costs in each section or department or job.

MR. BESWICK, replying, said that the Bedaux system was quite unknown to him until about nine or twelve months ago—which was some years after he had first put his own scheme into operation—and he had been surprised to find that in some fundamental respects the two schemes ran very nearly parallel. The aim, in his case, was simplicity. He was not sure that all the records obtained normally by means of the more involved systems were required every week; if anything were wrong the efficiency figures would reflect it, and then, in order to find the reason for it, one could extract detailed returns from the figures available, but it seemed waste of time to work out all those figures every week. He personally did not like bonus schemes as against straight piece-work; neither did he care for the practice of giving to indirect labour a percentage on the extra earnings of direct labour, because such a scheme suggested to the workman that he was working for the other men after he had reached his qualifying output, and, as a result, even though he was working for himself as well, he would slow down. At any rate, that had been his (Mr. Beswick's) experience with somewhat similar methods of payment in the past.

With regard to comparisons, he said that the most valuable comparison one could make with an efficiency record was that of the total time paid for and the total time value of the work done. That was a definite guide whatever the causes of the variations. Again, he suggested that his system did give the value of work in progress without extra accountancy, because the practice was to plot a wages curve and, below it, an efficiency curve, and the distance between them gave a measure of the work in progress. The distance between the two curves was checked with the stocktaking figures. He compared the distance between the peaks of the two curves for one week with the distance between the two curves for the next week, and knew at once where he stood in this matter; that seemed to be a much easier method than any accountancy method for summing up the week's work in progress. He objected to any system that multiplied clerical work. His aim was to reduce as far as possible the number of clerical workers, and indeed, if his system had involved the whole of one clerk's work he doubted if he would have been allowed to work it.

MR. W. F. DORMER, discussing the value of rest periods, expressed the view that a rest period of five minutes in a working period of five hours was not sufficiently long to affect the efficiency. He was in favour of the five-day working week, and, as the result of his experience, he maintained that, provided the total wages received by the men were not less than for a five-and-a-half-day week, the output should not be less, but should improve. With regard to holidays, he recalled that it was the practice, in one of the shops in which he had been interested some years ago, to pay wages in respect of all national holidays, and it was found that the employers did not lose money or production as the result.

MR. BESWICK agreed that a rest period of five minutes in five hours was not sufficiently long to affect the efficiency. He had raised this question only because his system did provide a means of ascertaining whether or not longer or shorter rest periods were advantageous. Previously there had been no definite method of measurement, and, although a lot of enthusiasts maintained that the men did work harder as the result of rest periods, the employers really did not know whether or not they were getting better results. His Company were among the pioneers of the five-day week, and they actually paid the men more for the five-day than for the five-and-a-half-day week. The figures for the five-and-a-half-day week in a shop he had previously run showed a definite decrease of efficiency on Saturday mornings and on Mondays, as compared with the remainder of the week, but with the five-day week in the shops he was now running, there was no appreciable drop at any time of the week, the efficiency remaining reasonably uniform throughout. It was his experience that efficiency increased just before the statutory holidays, the men trying to make a little extra money, but invariably there was a decrease afterwards, for a few days, because the men could not get into their stride again. He was trying to cure that, but it was difficult. The average efficiency of the week before and the week after a statutory holiday, however, taken together, was about the same as the average efficiency at normal times. Instead of paying for statutory holidays, his firm allowed the whole of August week as a paid holiday.

MR. E. J. JONES, who was particularly impressed by the simplicity of the system applied by Mr. Beswick, said that production engineers were apt to pay too much attention to the efficiency figure of 60 per cent. That figure did not matter two hoots, so far as he was concerned ; it was the other 40 per cent. that mattered, and production engineers should pay proper regard to that and find out where it was going. Mr. Beswick could assist them greatly, therefore, if he could indicate how he looked after that 40 per cent.

MR. BESWICK replied that if one were steadily increasing the efficiency from a given percentage upwards, one knew very well that

the adverse percentage was being steadily reduced. With operator efficiency averaging 80 per cent., say, one had a loss of 20 per cent. which represented time lost through tools breaking, jigs requiring adjustments, men leaving the shop, and so on. It was important to reduce such losses, and one was more likely to reduce them if the records were available to indicate to what extent they were occurring and whether increasing or decreasing as a result of any efforts one might make.

MR. A. T. S. GROOMBRIDGE suggested that, on the adoption of a 45-hour week and the consequent elimination of Saturday work, there would be a reduction of efficiency on Friday afternoons comparable with that which occurred on Saturday mornings in shops where the men worked the five-and-a-half-day week. He asked, therefore, if Mr. Beswick had made a direct comparison between the efficiencies on Friday afternoons in five-day-week shops and Saturday mornings in five-and-a-half-day week shops.

MR. BESWICK replied that by means of his system he could ascertain hour-to-hour or half-day efficiencies, and in fact, he did so occasionally, and found that the morning and afternoon efficiency figures were practically uniform throughout the week in the five-day-week shops. He had previously applied his system in a five-and-a-half-day week shop, and had ascertained that there was a reduction of efficiency to the extent of about $7\frac{1}{2}$ per cent. on Saturday mornings; that was a different shop, however, from that in which the five-day-week was adopted, and there may have been special circumstances affecting the results. Inasmuch as he had not applied his system in any shop in which there had been a change from the five-and-a-half-day week to the five-day-week, he had been unable to make a direct comparison between the Friday afternoon and Saturday morning efficiencies. In his five-day shop there was no measurable reduction on Friday afternoons. Usually the efficiencies were uniform to within $1\frac{1}{2}$ or 2 per cent. throughout the week—unless there was some big distraction outside.

MR. C. C. FERGUSON asked whether the change-over from the five-and-half-day week to the five-day week had been made at Mr. Beswick's works before or after the introduction of the $47\frac{1}{2}$-hour week mentioned in the Washington Hours Convention. He also asked whether the products made at the works were sold in the home market only or whether they had to meet foreign competition. Although Mr. Beswick had said that, when working for 45 hours in five days, the men did not slack off, it was the view of many who had experience of shops, and it was the view of trades union organisers also, that eight hours constituted a full day's work. It appeared, therefore, that shops which introduced the five-day week would have to reduce the number of hours to 45 per week, and it was important to consider the effect of that upon our exporting industries, having

regard to the fact that our competitors abroad were working considerably longer hours.

MR. BESWICK said that the adoption of the 45-hour week at his works was subsequent to the introduction of the 47½-hour week. His works were concerned with light manufacture; whether or not the five-day week, involving a nine-hour day, would be as advantageous in heavy manufacturing, with its greater fatigue, he was unable to estimate. The products of his works were not exactly sheltered, but he had in certain cases, found it possible to make fittings, on the basis of a 45-hour working week and average piece-work earnings of 70/- per week for unskilled labour, and to supply the Company's houses in Germany and the United States in better quality and at comparable prices to those at which they could buy similar fittings there. About one-third of his output was exported. He did not think a nine-hour day would be found too long when compensated for by a long week-end.

MR. HAWKINS asked whether the records from which Mr. Beswick built up his figures were piece-work tickets, stores receipts or other documents, Again, he asked whether the pay-roll clerks did the clerical work necessary in connection with the efficiency records also, or whether there was a separate organisation for making up the pay-rolls. With regard to setters, shop-cleaners, etc., he asked whether they were paid on a piece-work or bonus system, and, if so, on what basis were their earnings arrived at. The speaker also asked Mr. Beswick to give an example of the manner in which he made his calculations for any particular shop. He added that some interesting results were being obtained by the application of a system, the purpose of which was to ascertain the amount of time during which the machines were actually cutting metal, because it was only when they were actually cutting that they were earning money.

MR. BESWICK, replying said that the piece-work returns were obtained from piece-work tickets, checked by the stores; there was an intermediate store into which the work was sent after the completion of operations, and the returns were received from that store. Workers engaged in unskilled services were paid the same as the unskilled piece-workers. There was a system by which the total money earned by productive workers was pooled and divided by the total hours worked, and the workers whether productive or not received the quotient per hour. This encouraged co-operation. He gave an example of the calculation by which he arrived at his efficiency figures, and, in reply to a question as to the steps taken to ascertain whether he had too much or too little service, he said that the practice was to reduce services until it was found that the efficiency was affected; when the efficiency began to decrease he would know at once that he was going too far in the direction of reduction of services. He was less concerned about idle machines,

because orders fluctuated so, and had to be executed so rapidly, that the plant must be available at all times. In such cases it was preferable to have capital standing idle in machines that were available when needed than in the heavier stocks that would otherwise have to be carried to meet sudden demands.

MR. MELVILLE SMITH, referring to the tendency for the efficiency of a shop to be reduced on Saturday mornings, said that an experiment carried out at his works had indicated a reduction of nine per cent. in operator effectiveness on Saturday mornings, this figure being an average over a period of about three months.

MR. PUCKEY advocated that the efficiency should be calculated on the basis of price rather than time. He had been grading the labour into grades 1, 2 and 3. A grade 3 man, for instance, might be allowed a certain amount of time in which to machine a certain number of pieces, and the price per piece would work out at a definite figure. If a grade 1 man did similar work, however, he would play havoc with the price. Thus, if one calculated efficiency on the basis of price—which, after all, was the ultimate factor—the result would be different from that arrived at if the calculation were made on the basis of time.

MR. BESWICK replied that with his system it did not matter whether the basis was time or price, because time and price were directly related. It appeared to him that when varying rates were introduced, one was almost driven for the purpose of efficiency comparisons, away from the price basis and back to the time basis, which did not vary. The proportion of grade 1, grade 2 and grade 3 men in a department might vary from time to time, and the efficiency figure would vary accordingly if it were based on price. He wanted to know how much time he was paying for, and the time value of the work he obtained for it.

MR. BARKER said that the Bedaux system provided a means of ascertaining the efficiencies of individual operators, which was sometimes important, and he asked if Mr. Beswick's system also provided such information. The Bedaux system enabled one to ascertain quite easily what the efficiency was, when varying rates were paid, so that it satisfied the demands of Mr. Puckey. Mr. Beswick's system was quite sufficient for perhaps a comparatively small works. In a large works, with various departments, various grades of labour, and so forth, the Bedaux system was valuable, because it would give automatically an indication of what was happening all round, and would indicate to the management the individual efficiencies, supervision efficiency, and so on.

MR. BESWICK replied that he did calculate the efficiencies of individuals when desirable, but not as a routine practice. He had the necessary figures recorded, and whenever he had reason to suspect that a man or a gang was inefficient he could obtain from

those figures the efficiency of that man or gang during any previous week. He added that he could produce weekly returns of individual efficiencies, but he saw no reason to do so. He would have to employ more clerical assistance, and why should he produce 99 returns which he did not want for every one that he did want? His system had originally been run in a works employing more than 1,000 men, and was then managed by two part-time clerks, so that is was applicable to larger works. It should be applied departmentally, each shop being taken as a unit. They had to keep the necessary records anyway, large or small. It was only a question of the use they made of them.

MR. COX asked if Mr. Beswick would exhibit forms by means of which his system was worked. Commenting upon Mr. Beswick's statement that orders were received at his works spasmodically and that machinery had to be available always to enable them to be executed promptly, he asked if Mr. Beswick was always looking for fresh labour, under those circumstances, and, if so, whether he was able to maintain the efficiency when that labour was obtained.

MR. BESWICK replied that there were no forms introduced at his works beyond those in use before the introduction of the system, but a suitably ruled loose-leaf ledger was used for the purpose of totalling the weekly returns. He agreed with Mr. Cox that the engagement of a large number of new workers at any time did result in a dilution of the efficiency figures, and that the normal efficiency figures could not be attained again for several weeks. In order to overcome that difficulty it was preferable to engage such new men as probationers, and they were not engaged on piece-work until able to exhibit a piece-work effort.

MR. GROOMBRIDGE asked whether it was Mr. Beswick's practice, when calculating the efficiency of a shop, to deduct from the returns the output of the so-called probationers, and the time they expended on the work. He also asked how Mr. Beswick arrived at the efficiency of a shop which had to produce batches of articles which were never repeated.

MR. BESWICK replied that the figures of output of probationers were kept separate from the efficiency records. With regard to orders, he said that the quantities varied from five or six thousand of a particular article per day throughout the year down to fifties, dozens and single articles. For the production of these latter special articles, a special gang was maintained. This was a nucleus gang, and any one of the men in it could be transferred to the main piece-work gang at any moment. When a man was transferred from the main work to special work he clocked off the main work, and the special or jobbing work was not included in the efficiency returns. He agreed that it was difficult to run a manufacturing and a jobbing shop together, but it had to be done in such cases, only you could not

easily measure the efficiency of the jobbing half.

MR. COX asked whether the efficiency figures for the various shops were truly comparative and whether they indicated that it would be more profitable to carry out a particular job in one shop than in another—for example, that a particular article should be made as an auto job or a press job. He also asked whether the press shop efficiency figures related to hot or cold pressings separately or to hot and cold pressings combined. Finally, he asked if Mr. Beswick had studied the effect of allowing the men to smoke throughout the day, or at stated intervals.

MR. BESWICK said that his decision as to whether a particular article should be made on capstans, autos or presses must depend on which was the right way to do the job, and he would not expect to have to consider the relative efficiencies of the various sections. Other things being equal, a higher efficiency record would determine the matter, but other things were, in his experience, rarely equal. With regard to smoking, he said that the men at his works smoked all day, but he would prefer that they did not; his advice to any who contemplated allowing that privilege was to abstain. The press shop efficiency he had given was that of a cold press shop. He did not run a hot press shop also, and as a matter of fact the efficiency there was about five per cent. higher than that of any other shop.

MR. C. C. FERGUSON asked if Mr. Beswick had any system of paying tool-room men and millwrights by results.

MR. BESWICK replied that his view was that it was generally difficult to pay tool-makers on the piece-work basis unless their jobs were repetitive; there could not be piece-work unless there were pieces.

MR. BARKER said that at his works there was a system in vogue whereby, when a new job was to be commenced, the tool-room labour required for the maintenance of tools was fixed as a percentage of the productive labour. In the same way, in respect of the millwrights, the time fixed for overhauling old machines and for maintenance was a percentage of the productive labour, and the system was working very satisfactorily. The labour of electricians, viewers and setters was also gauged as a percentage of productive labour.

MR. BESWICK replied that in his opinion it was better to employ a first-class tool-maker, to leave him to do the job, and pay him his market value, than to try to force the job and perhaps to incur heavy overheads by employing people to go through drawings and estimate the tool-maker's prices for particular jobs. It seemed better, if one could, to add some of those overheads to the skilled man's wages.

MR. HALLIWELL said that some years ago he had tried out a time-unit system, though in a much milder manner than Mr. Beswick had done, and he emphasised that the Institution should appreciate the fact that Mr. Beswick had definitely proved his system to be

extremely efficient. One of the good points about it was that it provided a check against the responsible heads of the departments, as distinct from the operators, and he would like to be able to carry the system still further, if it were possible, and to apply the same principle to establishment charges, which constituted a very important factor in any production efficiency. He asked Mr. Beswick if, and to what extent, his system made provision for abnormalities in the condition of materials. For example, one batch of castings might have harder skins than another, so that the efficiencies were affected, and he asked how Mr. Beswick determined to what extent variations of efficiency were due to the operators and to what extent they were due to the materials.

Mr. Beswick said it seemed well nigh impossible to obtain an efficiency check on establishment charges; one could not use a stop-watch in respect of clerical work, and say that a certain amount of clerical work should occupy a definite number of minutes. With regard to the effect of variations in the hardness of materials, he said that, after all, there was an average. If there were a batch of hard castings at one time or in one part of a shop, no doubt the efficiency suffered as a result, but, on the other hand, it was almost certain that there would be a batch of soft castings at another time or in another part of the shop. He had learnt early to refuse to listen to complaints about hard material; after all, the men never complained when they received soft material, and it was a case of what was lost on the swings was gained on the roundabouts. Allowances might have to be made for extra difficulties due either to defect in materials or in earlier operations. Such allowances should be booked against running order numbers so that one could know the amount for which supplies were to blame over a period, and whether the defect originated in the shop or outside.

Mr. E. Ring, discussing the payment of tool-room workers, said that for the past two years or so a piece-work system of payment had been applied to more than 200 such workers at his works, and it had been concluded that the application of such a system was merely a means of paying the men a little more money than they had received formerly for the same output.

Mr. Beswick replied that he had tended to arrive at a similar conclusion on theoretical grounds.

The meeting concluded with a vote of thanks to Mr. Beswick.

SECOND ANNUAL MEETING AND SUPPER, LUTON, BEDFORD AND DISTRICT SECTION.*

SIR WALTER G. KENT, C.B.E., was the principal guest at the second annual meeting and supper of the Luton, Bedford and District Section of the Institution, at the Red Lion Hotel, Luton. There were other distinguished visitors, and Mr. R. W. Bedford, O.B.E., had the pleasure of presiding over a company numbering over eighty. The success of one of Luton's newest and most helpful organisations must be a source of great gratification to him, and to all concerned in its management, and it is hoped that one result of the section's latest function will be a considerable increase in the membership.

Among those present, in addition to Sir Walter, were Mr. Legros, past President of the Institution of Automobile Engineers; Professor H. Stanley Jevons, Mr. E. W. Hancock, works manager of the Daimler Motor Works, Coventry, and formerly with Vauxhall Motors Ltd., Mr. H. E. Weatherley, president of the London section; Mr. W. Groocock, president of the Birmingham section; Mr. W. F. Dormer, president-elect of the London section; Mr. R. Hazleton, general secretary to the Institution; Mr. S. Carlton Smith, president-elect of the Luton section, and Mr. F. W. M. Lee, hon. secretary.

Successful Year's Work.

In his presidential address, Mr. Bedford spoke of his term of office as a very happy one. He thanked the members of the Committee for their support, and said the meetings had been well attended, and the papers varied and interesting. Sir Walter Kent had taken a very keen interest in the progress of the section, and they were honoured to have him as their principal guest—(hear, hear and applause). He considered the Production Engineers an important and useful Society which had filled a gap between the older and what one would call the professional institutions. The section now numbered fifty members, which was very creditable, and membership of the Institution carried a status which was now recognised throughout the engineering profession.

Mr. Bedford welcomed Mr. Hancock, Mr. Weatherley, Mr. Groocock and Mr. Hazleton. The presence of these members of the Council was a great compliment to them, and indicated that their confidence was not misplaced when they decided to start a section in Luton. The membership of the Institution now numbered over 600. The finances were sound, and the Council was composed of gentlemen who had one interest, to place the Institution in the forefront of the engineering societies of the country—(applause).

**29th April, From the report published by the Luton News*

A visit to Loughborough Engineering College had been arranged for Saturday, July 11th. Luton hoped to send a large party, and ladies were invited.

The New President.

Before sitting down, Mr. Bedford proposed Mr. Stanley Carlton Smith as his successor in the presidential chair. From the very start of the section, he said, Mr. Carlton Smith had been one of the hardest workers.

Mr. F. Siddall seconded, and the unanimous acceptance of the resolution was acknowledged by Mr. Carlton Smith. He paid tribute to the work of Mr. Bedford, and mentioned that Mr. Bedford had consented to serve on the Committee during the coming session. The policy of the Committee would therefore be to carry on with renewed efforts on exactly the same lines as heretofore.

Mr. Bedford was unanimously elected a member of the Committee. Mr. Siddall was re-elected, and new members appointed were Messrs. E. Larsson and R. Broomhead.

Asserting, as the Billingsgate porter said of his mate, that Mr. Bedford had used all the best words, Mr. J. Ronald was very brief in submitting the toast of the Institution. Though short, his speech was notable for the coining of a new word. The Institution, he claimed, deserved the support of all productioneers.

Compliments from Coventry.

"I think the Luton section is to be highly complimented upon this particular function," was the graceful opening of Mr. Hancock's reply. Mr. Hancock expressed hearty appreciation of the interest Sir Walter Kent was displaying in the Institution, and remarked that it was not the first occasion on which he had given up his time to interest himself in it. The Institution was something which had come to stay. They had their older institutions, which were unquestionable in their class, but, primarily, they were theorists. The Institution applied that theory. They had to convert the ideas and schemes of the ingenious brains of this country into actual facts, and he was confident that there had been a need of the Institution for many years.

To-day the two words on everybody's lips were production and salesmanship. When he spoke of salesmanship he did not mean the sock and hair oil merchant who persuaded the local vicar to buy a sewing machine—(laughter). He spoke of men who were going out to investigate the soil, to tell them what seeds they must make to sow in the soil. There was no question that this country was making many wonderful articles at a good price, but there was no market for them. His inspiration for saying these few words was the inspiration given to them by the Prince of Wales—(hear, hear and applause).

In his Royal Highness they had a man who knew what was needed, and they must, in every phase, try to force the issue in regard to sales.

"A Product of Luton."

Reverting to his original theme, Mr. Hancock repeated that the Institution had come to stay, and was being recognised everywhere. "I speak to you to-night as Chairman of the Council, president of the Coventry branch, and, perhaps of most importance, a product of Luton," he concluded. "I served my time here as a youngster of 14 years of age, and I have many associates here, and nothing gives me greater pleasure than to come this evening and be among you in this town, which has given me the necessary engineering education, and helped me to get some way up the ladder of production engineering"—(applause).

"Our Guests" was the subject to which Mr. Carlton Smith related his remarks. He mentioned them by name, and dwelt on the sincere and hearty interest Sir Walter Kent had taken in the Institution, and the valuable help and encouragement he had given to the Luton section. If what had been achieved had been done by hard work, under the inspiration of Mr. Bedford, he was sure Mr. Bedford would agree that behind his inspiration was the genius of Sir Walter Kent—(applause).

Sir Walter's Appreciation.

A reply that was witty and felicitous came from Sir Walter. After expressing the thanks of the guests, he said that one or two all too kindly references had been made to what interest he had been able to show in the work of the production engineers. He did not think it was a very altruistic interest. He thought that anybody who was concerned in any sort of engineering business to-day owed to all of them the deepest debt of gratitude for the inestimable benefit they bestowed on that great profession. Without their work it would be utterly impossible to-day for any English engineering business to compete for a moment with the productions of America and the Continent. He felt that to aid and further the work they did was one of the things that all who loved their country could devote themselves to heart and soul, knowing there was no better work for them to do. If he could help in any little way it was not only one of the most pleasing and self-satisfying things he could do, but he knew that in doing it one was helping, not only one's self, but the industry of the country at large—(hear, hear and applause).

Ample opportunity was given for entertainment by the Tudor Singers, and, as they were in brilliant form, their numbers met with very cordial appreciation. Their programme was well varied, and was rendered with an artistic finish that made it a positive delight.